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THE GEOMORPHOGENY OF THE TEHACHAPI VALLEY SYSTEM.

BY

ANDREW C. LAWSON.

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INTRODUCTION.

At the southern end of the Sierra Nevada there are certain high valleys, situated about 4000 feet above sea level, which, by reason of their abnormal position, their peculiar drainage, their large dimensions, and their discordant relation to their geomorphic environment, invite geological inquiry as to their genesis.

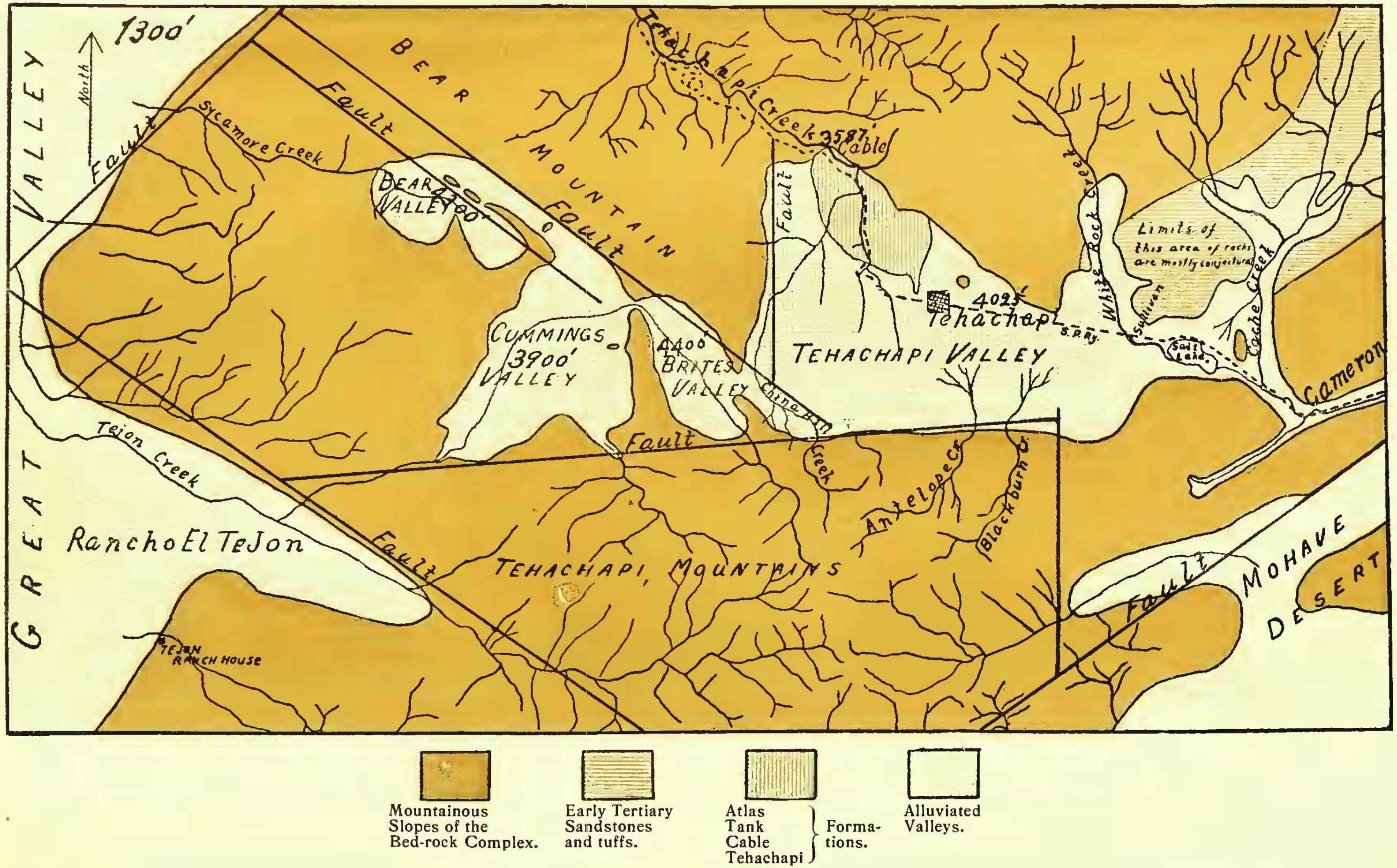
The largest of these valleys is Tehachapi, and, as it forms the pass over the mountains for the railways connecting the Great Valley with Southern California, it was the first to attract the attention of the writer. An attempt to get familiar with its features led to the discovery, however, that it was but one of a system of similar valleys which characterize the region. In the country to the west of Tehachapi lie Brites Valley, Cummings Valley, and Bear Valley. It is the purpose of this paper to give a brief descriptive account of these valleys, to indicate something of their geological history and in so doing suggest at least a partial explanation of their rather unique features.

TEHACHAPI VALLEY.

General Features.—Tehachapi Valley is situated on the summit of that portion of the Sierra Nevada which lies between the southern end of the Great Valley and the Mohave Desert. Its extent from east to west is about 12 miles. Its breadth in its middle part, at the town of Tehachapi, is about $4\frac{1}{2}$ miles. At its west end it is 6 miles wide and at its extreme east end it narrows to about half a mile. It has thus in ground plan the form of a right angled triangle, the right angle being at the southwest corner of the valley. Its area is about 36 square miles.

The boundaries of the valley are for the most part bold mountain slopes, which rise to crests at no great distance from the valley. The area of the hydrographic basin in which the valley lies is about 130 square miles. From this statement it will be apparent that the streams which flow into the valley from the surrounding mountains are small. The annual rainfall is $10\frac{1}{2}$ inches.

Streams.—Of these streams the two largest are on the north side of the valley toward its east end, and are known as Cache Creek and White Rock Creek. Both of these enter Tehachapi Valley through trumpet-shaped side valleys, which in their stage of geomorphic advancement and in their degree of alluviation are seemingly homologous to, and harmonious with, the main valley to which they are tributary. These tributary valleys are of the nature of embayments in the mountains on the south, and,



Mountainous Slopes of the Bed-rock Complex.	Early Tertiary Sandstones and tuffs.	Atlas, Tank, Cable, Tehachapi } Formations.	Alluviated Valleys.

Physiographic Sketch Map of the Tehachapi Valley System showing their relation to the Great Valley and to the Mohave Desert.

Scale: 1 inch = 4 miles.

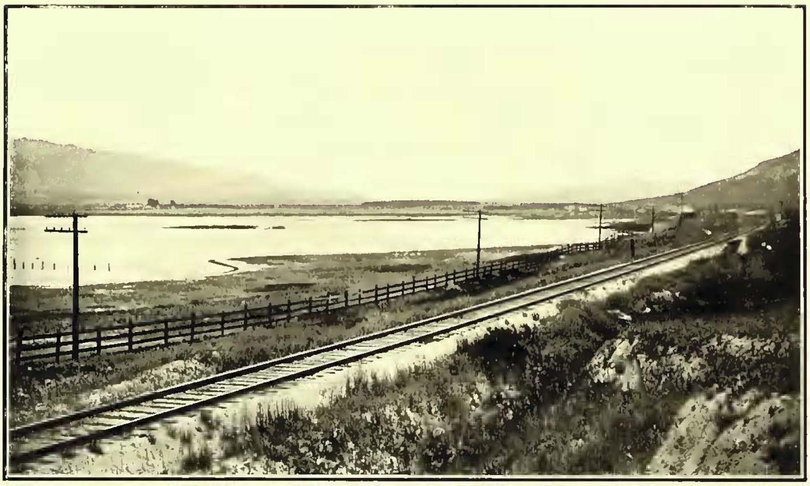
as their floors are accordant with the floor of the main valley, they cause the ground plan of Tehachapi Valley to have in this part a distinctly indentate contour. There are three notable streams entering the valley from the high sharp mountain ridge which forms the southern boundary of the valley in its western part. These are from west to east, China Hill Creek, Antelope Creek, and Blackburn Creek. These three creeks are in marked contrast to Cache Creek and White Rock Creek on the south side. They emerge upon Tehachapi Valley through narrow rocky gorges, whose bottoms are not yet cut down to the level of the main valley floor, and the alluvial fans which they have built up apex wholly outside of the mountain pass, within the confines of the valley. These cañons are so narrow that they effect no appreciable indentures in the ground plan of the valley boundaries, and the mountain front is here remarkably even and straight, as well as steep.

Alluviation.—The floor of Tehachapi Valley is for the most part a surface of alluviation, and appears to the cursory glance uniformly flat. Unfortunately the region has not yet been topographically mapped and we have, therefore, no exact measure of the slopes of this apparently flat floor except such as are afforded by the railway levels. The altitude at Tehachapi station is 3963 feet; at the summit, 2 miles to the east, it is 4025 feet; and at Sullivan's, $3\frac{1}{2}$ miles from Tehachapi, it is 3980 feet. These figures give the altitude of the central part of the valley along its north side, which is the lower side. From the line of the railway the floor of the valley slopes up to the south on the surface of the confluent alluvial fans of China Hill, Antelope and Blackburn Creeks. In the eastern part of the valley, on the contrary, the alluvial fans of White Rock and Cache Creeks from the north dominate the slope of the valley and cause its lower part to be on the south side.

Between the alluvial fans of these two creeks there is on the south side of the railway a saline lake, the expanse of which varies with the season, but which at its largest is less than a square mile in area. This lake receives the waters of White Rock Creek. The waters of Cache Creek are sometimes shed down the west side of its fan to the lake and at other times to

the east side out through the rocky gorge at Cameron to the Mohave Desert, the position of the stream upon its fan being unstable and fluctuating. Usually the lake has no outlet and the waters are strongly saline. It is said that deposits of salts have been worked in the clays which underlie the lake to a depth of 8 feet. Occasionally, however, the lake appears to overflow around the lower edge of the Cache Creek fan into the gorge leading out to Mohave.

The depth of the alluvial infilling of the valley is not known. Certain wells that have bene sunk indicate that it is by no means a shallow veneer. A well sunk for water on the railway about three-quarters of a mile above Cameron at the extreme east end of the valley passed through 125 feet of alluvial gravel, sand, and clay without reaching solid rock. On Spencer's ranch a well was sunk for water on the northwest quarter of Section 34, Tp. 32 S., R. 33 E. This well is said by the driller to have passed through 10 feet of black clayey loam, then 125 feet of yellow clay with fine gravel, and then through 30 feet of gravel with coarse boulders at the bottom up to 10 inches in diameter. At this depth no water was found and for practical reasons the well was abandoned. Another well was sunk in the immediate neighborhood, to a depth of 344 feet through gravelly sandy and clayey alluvium, water being found at a depth of 248 feet and rising in the well to within 120 feet of the surface. In this well very few pebbles were found larger than one's fist and only rarely was a boulder found as large as a man's head. The writer visited the well and examined the material that had been taken from it. The well is situated less than a mile north of the base of the steep mountain slope which bounds the valley on the south. We have thus in the record of this well evidence that the alluviation of the valley reaches a depth of not less than 344 feet. Several wells have been sunk in the town of Tehachapi, and these are said to yield water first at a depth of 35 feet and again at about 90 feet below the surface. One well, however, is said to have been sunk to a depth of 166 feet, mostly in clayey alluvium with gravel at the bottom. The alluvial floor of the valley is in part suitable for cultivation, and the greater part of it is fenced for ranch purposes, but there are probably



A. Looking west across Tehachapi Valley from the east end. Saline lake in the foreground.

B. Southwest corner of Tehachapi Valley. Looking southwest toward the barrier which separates Tehachapi and Brites Valleys across the alluvial cone of China Hill Creek.

not more than a dozen ranchers actually engaged in the cultivation of the soil. Portions of it are, however, utilized as cattle ranges.

Another indication of the volume of alluvium in the valley is afforded by the dissection of the alluvial cone of Antelope Creek at its apex. Here Antelope Creek has greatly deepened its rocky gorge within the mountains since the apex of the alluvial cone was established, and this deepening of the gorge has necessitated the dissection of the cone. The extension of the gorge through the apex of the fan reveals a section of alluvium 250 feet thick above the stream. In the vicinity of the apex of the China Hill alluvial cone a much greater thickness may be inferred. Here the coarse gravels of the upper part of the cone have been hydraulicked for placer gold.

Isolated Hills.—An interesting feature of the valley floor is the occurrence of certain isolated rocky hills which project as island-like masses through the alluvium. There are two such hills of prominence, both on the north side of the valley and both composed of the granitic rocks of the surrounding mountains. One of these lies to the northeast of Tehachapi and less than a mile distant from the town. It rises to an altitude of perhaps 100 feet above the surrounding plain as a rugged more or less conical mass of bare rock. The other is at the east end of the valley and lies at its confluence with the wide-gaping tributary valley of Cache Creek. It is surrounded by the alluvial fan of that creek, the stream, which is now to the east of the hill, having formerly flowed to the west. The hill is about half a mile in length from north to south and about half as wide at its base and it is probably not less than 200 feet high, its bare rocky precipitous slopes being in striking contrast to the surrounding alluvial plain. The isolation of these hills from the neighboring mountain slopes affords additional suggestion as to the great depth of the alluvial infilling of the valley, and indicates something of the irregularity of the rock surface upon which the alluvium, in parts of the valley at least, rests. The best actual exposure of alluvium of the valley floor which came under the writer's observation was that afforded by a trench at the extreme eastern end of the valley at from one-half to three-quarters of

a mile above Cameron station. The trench is a new feature of the topography and was cut by the exceptionally heavy run-off due to the rains of the winter of 1904-5. The trench is 13 feet deep below the floor of the valley. In the bottom of the trench there is exposed a dark gray or drab-colored, stiff clay with remains of plant stems in it, to a thickness of 3 feet. Upon this clay with a sharp horizontal contact rests 10 feet of the ordinary alluvium of the valley, consisting of light colored granite sands with lenses of gravel. The contrast of this sandy and gravelly alluvium with the underlying stiff clay is significant of a change in the conditions of deposition. This contrast is the more significant when it is stated that the exposure occurs in the narrowest part of the valley, practically in its outlet to Mohave, the width of the floor here being only 200 yards, between steep rocky walls. It would be interesting to know the thickness of the clay, but unfortunately this could not be ascertained.

Remains of Mammoth.—About a mile and a quarter to the westward of Tehachapi station on the line of the railway, certain trenches were cut by the Southern Pacific Railway Company for the purpose of developing a supply of water for one of their tanks. In this work a large bone was found and was forwarded to the University of California by Mr. de Heur, the resident engineer of the company at Bakersfield. The bone has been identified by Professor J. C. Merriam as the tibia of a mammoth.* The writer subsequently visited the locality under the guidance of one of the workmen who was present when the bone was found. The trench is now boxed in, but enough of the section was seen to establish the fact that it cut through about eight feet of black adobe clay, then through three feet of yellow clay. This yellow clay rests upon gravelly alluvium, the rock fragments of which are angular and little water worn, and range in size from minute fragments with sand up to pieces the size of one's fist. The depth of this gravelly alluvium is not revealed. The mammoth bone was found at a depth of between 11 and 12 feet, or just below the yellow clay. The yellow clay and the gravelly alluvium represent with little question the lower edge

* This is now in the Collection of Vertebrate Palaeontology, Univ. Calif. Accession No. 9842.

of the China Hill Creek cone. But the black adobe clay is the product of more recent accumulation, under marshy conditions, due to springs, on the narrow flood plain of the modern creek where it has trenched the cone.

Rocks of the Surrounding Mountains.—The prevailing rocks of the mountains which encircle Tehachapi Valley, as well as the other valleys to the west of it which are described in this paper, are those of the Bed-rock Complex of the Sierra Nevada. They comprise a series of metamorphic rocks, represented chiefly by crystalline limestones and mica schists with quartzites, and various plutonic irruptives of granitic habit which have invaded the metamorphic series. The limestones occur in isolated patches in numerous localities and appear for the most part to be large inclusions which sank down into the granite when the latter was viscous. The mica schists occur in more persistent belts of no great width. Both limestones and schists have a persistent north and south strike with easterly dip at angles of from 45° to 60°, though sometimes vertical. The granitic rocks, however, greatly preponderate throughout the region, and constitute the great bulk of the mountains. The limestone is quarried at a number of localities, but most extensively at the mouth of Antelope Cañon to the south of the town of Tehachapi where it is burnt for lime.

The superjacent series of the northern portion of the Sierra Nevada is represented in this region by two formations of stratified rocks, which rest unconformably upon the Bed-rock Complex. The lower of these is well exposed in the middle and upper parts of the tributary valley of Cache Creek. It consists of a great volume of coarse arkose sandstones and conglomerates with some thin beds of sandy shale. On the northwest side of the middle part of Cache Creek they dip at an angle of 60° to the southeast, and their superposition upon the granite is well exposed. On the east side of Cache Creek these sandstones appear to dip to the northwest and to strike to the northeast, curving around the granite traversed by the creek in its lower part. In certain of the shale beds referred to there are abundant fossil leaves in a good state of preservation, and their occurrence here renders it probable that the formation is a fresh-water

deposit. The age of the beds is not known but it is probable that they are early Tertiary. The second formation of stratified rocks is well exposed in the vicinity of Sullivan's station and thence up White Rock Creek. It is probably stratigraphically above the sandstone and conglomerate formation of Cache Creek but this was not certainly determined. The formation is almost wholly made up of regularly stratified volcanic tuffs and agglomerates, well cemented, but there are with these near Sullivan's station some beds of greenish gray sandstone which may be composed only in part of volcanic ash. These stratified tuffs and agglomerates lie in a well marked syncline, the axis of which pitches to the northeast. The formation lies chiefly in the country between White Rock Creek and Cache Creek, but the nose of the syncline above referred to crosses White Rock Creek, toward the west, and in this direction one passes in a few hundred yards from the tuffs to the underlying rocks of the Bed-rock Complex. The dip of the strata on the southern limb of the syncline, near Sullivan's, is from 25° to 30°.

The most interesting feature of these superjacent formations is their degree of deformation, and the evidence that they thus afford that orogenic movements have occurred in the southern end of the Sierra Nevada which seem not to have affected the same series in the middle and northern part of the range. That is to say, while the superjacent series in middle and northern California have been profoundly faulted by the movements which gave rise to the Sierra Nevada tilted block, there appears to have been no folding of such rocks; while here on the north side of the east end of Tehachapi Valley the evidence of flexure is marked.

Outlets of Tehachapi Valley.—Perhaps the most remarkable feature of Tehachapi Valley is the fact that it has two outlets. Both of these are incisive stream gorges cut in the granite rocks of the Bed-rock Complex. One drains the western portion of the valley to the Great Valley and is occupied by Tehachapi Creek which leaves the valley at its northwest corner. The other drains the eastern part of the valley to Mohave Desert. The Tehachapi Creek gorge has a higher grade than that leading out to Mohave, carries more water and is more sharply cut. The cañon draining

out to Mohave is wider in its bottom, carries little water except during heavy rains, and in its upper part is encumbered with stream gravels and sands. In its lower part, however, the grade becomes too steep for this stream drift to linger on the cañon floor and the stream runs on bed rock. On the whole, the Mohave outlet of the valley presents a more mature aspect than the gorge of Tehachapi Valley. The divide between these two drainages lies in the nearly flat, expansive, alluviated floor of Tehachapi Valley near its middle part. The explanation of this anomalous drainage must be deferred till certain other features of the geology of the valley are presented.

Although the fossil leaves of the sandstones and shales of Cache Creek indicate that they were laid down in a fresh-water basin, it is not supposed that this basin had any structural relation to the present Tehachapi Valley. The Cache Creek beds are apparently much more extensive to the northeast than the limits of the valley in that direction. Cache Creek Valley, moreover, is a valley of erosion cut in part out of the sandstone formation. As will be seen later there is ground for believing that Cache Creek Valley, as a geomorphic feature, probably ante dates the main Tehachapi Valley. The tuffs and agglomerates of White Rock Creek are probably of about the same age as the sandstones and were doubtless laid down in the same basin.

In the northwest corner of Techachapi Valley, however, there is a group of formations which seem to have a somewhat more intimate relation, as regards their basin of accumulation, with the present Tehachapi Valley. These formations will be first listed in the order of age and their characters and relationships will then be briefly reviewed:

1. An Ancient Alluvium, here designated the *Atlas Formation.*
2. Andesitic lava flows and tuffs, here designated the *Tank Volcanics.*
3. Fresh-water lake beds, here designated the *Cable Formation.*
4. Post-lacustrine alluvium, here designated the *Tehachapi Formation.*

Atlas Formation.—This formation is known from three exposures, one at the nose of the ridge one mile west of Tehachapi station on the north side of and immediately adjacent to the railway; another in the cut one-eighth of a mile below Cable, just north of the steel bridge; and the third in the bottoms of certain cañons tributary to Tehachapi Creek on the east side of the railway and about midway between Cable and Tehachapi stations. In all three of these exposures the formation has the same characters and the same stratigraphic position. It is made up of angular fragments of rocks of the Bed-rock Complex including schists, quartz-diorite, granite, etc., pieces of quartz and considerable granite sand or arkose. The fragments are frequently from 6 to 12 inches in diameter but are prevailingly less than 6 inches across. This aggregate presents the normal characters of a typical alluvium, such as is deposited at the mouth of a high grade, short mountain stream. This alluvial debris has been well cemented; but since its cementation it has been thoroughly decomposed, so that the blocks and smaller fragments of the crystalline rocks are now soft and incoherent and crumble under the pressure of the fingers. Independently of the stratigraphic position of this formation, it is easily recognized and distinguished from other alluvial accumulations of the region by these two characters: viz: its cementation and its decayed condition. In the railway cut one-eighth of a mile below Cable, near where one enters the rocky Tehachapi cañon, there are exposed 12 feet of this formation. Above it and resting stratigraphically upon it are 3 feet of yellowish white volcanic tuff; and above this there is a thick sheet of andesitic lava. There is no doubt, therefore, that the alluvium antedates the only volcanic rocks that are known in the region.

The same relations are revealed in the cañons east of the railway between Cable and Tehachapi. Here the streams have cut down through stratified tuffs into the Atlas Alluvium which is thus revealed to a thickness of perhaps 30 feet.

The thickest exposure of the formation is the first one mentioned at a point about a mile west of Tehachapi station. Here there are about 50 feet of the formation shown in the railway cut and in the adjacent steep slopes. A little beyond this point

on the railway grade there is exposed an area of 20 or 30 acres of andesitie lava whieh probably overlies the decomposed alluvium. The entire absence of fragments of lava in the alluvium, although carefully looked for, is in aecord with this interpretation whieh is, however, based on independent structural evidence.

Tank Volcanics.—These roeks are best exposed in the vicinity of the railway tank whieh is situated about 2 miles below Tehachapi station on Tehaehapi Creek. The lava is exposed over an area of 20 or 30 acres with a slope of 5° to the west and a vertieal range of about 150 feet. Its relations here are not as well revealed as in other localities, but it appears to rest in part upon the Atlas Alluvium mentioned above, and is eertainly below the Tehachapi formation. The Cable formation is not here exposed.

Another oecurrence of the lava is on the west side of Tehaehapi Creek to the west of the high ridge, eomposed of the Cable and Tehachapi formations, which is situated southwest of Cable station. Here the lava rests upon an old surfaee of the Bed-rock Complex eomposed of granitie roeks, schists and erystalline limestone and is clearly stratigraphieally below the easterly dipping beds of the Cable and Tehaehapi formations. A third occurrenee has already been mentioned in speaking of the exposure of the Atlas Alluvium below Cable. Here it was stated that the Atlas Alluvium was overlain by a bed of yellow tuff and a thiek sheet of andesitie lava. The same seetion shows very clearly the superposition of the Cable lake beds upon the sheet of andesite.

The tuffs and agglomerates whieh lie upon the Atlas Alluvium in the eountry between Cable and Tehachapi station are without question to be eorrelated with the lava as part of the same voleanie extravasation. These voleanies as has been shown are elearly above the Atlas Alluvium; but they are no less clearly below the Cable lake beds which are well exposed by the same dissection as that which has revealed the underlying beds.

Cable Formation.—The roeks of this formation are best exposed in the vieinity of Cable station on both sides of the cañon of Tehaehapi Creek. They comprise limestones, cherts, gravels, elays, and fine light colored volcanic tuff. These roeks are for

the most part well stratified and have a thickness which is estimated at about 250 feet. Where the base is exposed, the formation rests in some places upon the Tank Andesite, as on the west side of Tehachapi Creek below Cable, in some places on a coarse agglomerate made up of andesitic fragments, and in other exposures directly upon the rocks of the Bed-rock Complex. In every case where it is exposed it is overlain by the alluvium of the Tehachapi formation. The limestones are cherty and contain fresh-water molluscan remains such as species of *Planorbis* and *Physa* in a good state of preservation. The clays are more or less admixed with fine volcanic ash and in such beds there are often remains of roots and stems which have been thoroughly silicified. Not only are the limestones cherty but they pass along the strike into beds which are composed almost wholly of evenly stratified light colored to white cherts. These cherts outcrop rather boldly and as they occur near the base of the series they facilitate the delimitation of the area of the formation. The pebble beds are not more than a few feet thick and are composed of smoothly rounded pebbles of small size. These beds of course indicate shallow water conditions and proximity to the shore line of the lake. The occurrence of volcanic ashes in the clays and as distinct beds may indicate a survival into the lacustral period of the volcanic activity, which gave rise to the pre-lacustral and underlying Tank Volcanics; but it may also be explained as due to the erosion of these earlier volcanic deposits. To the east of Tehachapi Creek these fresh-water beds strike southeast from Cable and dip southwest beneath the overlying Tehachapi alluvium at angles varying from 12° to 20°, for a distance of nearly 3 miles, beyond which the outcrop can no longer be followed with certainty. The strike at the point where the outcrop ends probably swings around to south and follows the lower east flank of the ridge extending toward Tehachapi station. To the west of the creek below Cable they dip southerly and thence going south the strike swings around to north and south with an easterly dip and at a point about a mile north of Cable station the dip of the beds is vertical. About three-quarters of a mile southwest of Tehachapi station near the cemetery there is an outcrop of calcareous clays from beneath the Tehachapi

The fresh-water limestones of the Cable Formation, south of Cable.

alluvium. These clays are probably a portion of the fresh-water formation and if so, they indicate a northerly dip of the formation.

It thus appears that the Cable fresh-water beds lie in an asymmetric synclinal trough, the nose of which is situated below Cable at the point where the strike changes its course from northwest and southeast to north and south. An interesting fact indicating at once the former extent of the lake beds and the nature of the deformation to which they have been subjected is the occurrence, on a spur of the mountains to the north of Tehachapi, at a point about 2 miles north of the station, of an outlying patch of cherts plastered as it were on the face of the mountain slope, the dip of the beds determining the angle of declivity. The projection of these beds to the northeast would carry them over the entire southerly slope of the mountains on this side of the valley.

Tehachapi Formation.—In the trough above indicated lies a great body of coarse alluvium, the Tehachapi Formation, reposing upon the Cable fresh-water beds and having approximately the same areal distribution as those beds. It is well exposed in many steep slopes and railway cuttings in the cañon of Tehachapi Creek above Cable. In these exposures it is seen to be composed of a coarse aggregation of rock fragments such as is usually found near the apex of the alluvial cone of a steep-grade stream. These rock fragments are in a fresh undecomposed condition and are but slightly cemented together so that separate blocks may be detached from the aggregate with ease. These materials comprise, not only granite rocks, schists, limestone and quartz of the Bed-rock Complex, but in certain portions of it there are numerous blocks of the Tank Andesite. In the lower part of the formation where it rests upon the uppermost beds of the Cable formation, the rock fragments are comparatively small, masses the size of a fist and less predominating and there is a considerable admixture of sand. Here the material is rudely stratified and where the contact is exposed in the railway cuts above Cable the dip of this stratification is the same as that of the underlying lake beds, about 12° to the southwest. In the higher parts of the formation the angular blocks of which it is

composed are much larger in size and in the highest portions spauls of rock 10 feet in diameter are occasionally met with while masses from 3 to 5 feet in diameter are quite common. In general, stratification is not apparent throughout the formation even in excellent exposures except at its base, as above mentioned, and it is difficult to estimate its thickness. Some idea of its volume may be obtained, however, from the fact that the highest part of the formation is 350 feet above the level floor of the valley at Tehachapi Station and assuming a gentle syncline for the structure of the formation as a whole this figure may be taken as a value for its thickness.

This thick accumulation of coarse alluvium is the record of an important event in the diastrophic history of the southern Sierra Nevada. It is considered by the writer to have been, anterior to its deformation and degradation, a great cone such as is found commonly where high grade streams emerge from narrow mountain cañons and spread out abruptly upon a lower grade valley. Their situation is always along lines of geomorphic discordance, or where the geomorphic features of the mountain are completely out of harmony with those of the adjacent valley from the point of view of erosional evolution. Such situations are produced by faulting or by other acute deformation of the region, whereby the mountain mass has been uplifted relatively to the valley. Occasionally a trunk stream may flow in a cañon which has been overdeepened relatively to its tributaries and the conditions may in such cases be favorable for the development of alluvial cones at the mouths of the hanging valleys. These conditions, however, are most commonly found in glaciated regions, and even then the geomorphic discordance between the overdeepened cañon and the tributary hanging valley is slight compared with that which obtains between the recently uplifted mountain ranges and the broad diastrophic valleys which parallel them in Southern California and in Nevada.

On the assumption which is here made of the strictly fluviatile origin of the Tehachapi formation it is evident that an acute deformation of the region occurred at the close of the Cable lacustral period, and caused a rapid dejection of coarse mountain detritus into the basin formerly occupied by the lake from

country where no high grade streams had previously existed. It is noteworthy, moreover, that the position of this coarse alluvial material, in the northwest corner of the present Tehachapi Valley, establishes the fact that its source was in the mountains to the south. In other words, it is clear that at the time of the accumulation of this great alluvial cone *the drainage was from the north,* and was approximately, in part, along the line of the present deep cañon of Tehachapi Creek which flows from south to north. The present drainage then, to the Great Valley of California has a direction which is the reverse of that which formerly obtained along the same general course. This fact is one of prime significance in any attempt to explain the present dual outlet of Tehachapi Valley.

But while it is clear that orogenic movements inaugurated the accumulation of the great cone, it is no less clear that orogenic movements subsequent to its upbuilding have deformed it. What is left to-day of the great cone is but a remnant of its original mass and extent. It now lies in a synclinal trough. Whenever its base is exposed it reposes upon the Cable lake beds and the rude stratification of the lower part of the formation where exposed above Cable Station is parallel to that of the lake beds. It probably nowhere extends at present beyond the rim of the synclinal trough formed by the lake beds. It certainly does not in the numerous and often persistent exposures where the two are seen in juxtaposition. The lake beds are nowhere horizontal but dip in all observed cases for several miles of outcrop on different sides of the trough under the alluvium, and on the west side of the trough they are well exposed in one locality in a perfectly vertical attitude. It is evident then that the whole body of the alluvium has been subjected to the same measure of deformation as that which can be made out clearly from the attitude of the underlying regularly stratified lake beds.

Planation.—Since its deformation the Tehachapi alluvium has been broadly terraced by stream action, the terrace has since been deeply dissected and the mass has otherwise been degraded by the forces of erosion. The broad terrace which truncates a large proportion of the total area of the formation is a most

interesting feature of the geomorphy of the region. The terraee is not eonfined to the alluvial formation, but extends, as a broad even plain, indifferently aeross the alluvium, the soft beds and hard eherts of the Cable formation, and the sehists, limestones and granite of the Bed-roek Complex. The terraee slopes down to the south at a low angle. Its expanse inereases also in this direetion and it eventually passes beneath the present floor of Tehaehapi Valley where it meets the opposite slope of the China Hill alluvial fan. The terraee beeomes eonstrieted to the north, and leaving the valley it passes into the mountains, whieh lie on this side of the valley, in the form of beneh-like remnants high up on the eastern slope of Tehaehapi eañon. Just before passing into the mountains north of Cable, it is bounded on the west for a short distanee by a sharp residual ridge of the Tehaehapi alluvium. Beyond the south end of this ridge, however, the terraee extends over to the steep, roeky mountain slope whieh forms the western boundary of the valley. On the east side of the railway above Cable, the stream whieh earved the terraee, in the eourse of its meandering and lateral eorrasion, eut an embayment over a mile in breadth out of the main mass of the Tehaehapi Alluvium. This embayment is bounded on the east and south by a relatively high semieireular residual ridge of the alluvium. This semieireular ridge, together with the similar residual ridge on the west side of the railway nearer Cable, are so disposed as to give these prominent residuals of the Tehaehapi alluvium the eonfiguration of a terminal moraine. This superficial resemblanee to a moraine is enhaneed by the numerous spauls of roek of eonsiderable size whieh weather out of the alluvium and lie strewn over its surfaee. The faets above eited prove, however, that the resemblanee to a moraine is quite superfieial and aeeidental as regards at least its form.*

It has been pointed out that the souree of the materials for the Tehaehapi Alluvium was probably in the mountains to the

* It is to be observed that on the basis of its composition alone there might be considerable doubt as to whether the Tehachapi formation were fluviatile or glacial in origin. But as the mountains of the region do not exceed 7000 feet in altitude, and present no traces of glacial sculpture, and as the material rests on a non-glaciated surface and is in part stratified, the writer was forced to reject the glacial hypothesis and interpret the accumulation as an alluvial cone.

A. Tehachapi Creek as it leaves Tehachapi Valley near Cable, showing the degree of dissection of the terrace shown in Plate 46.

B. Stream terrace near Cable on the sides of the cañon of Tehachapi Creek. The terrace slopes *up* to the north, the direction of the present drainage.

north of the present Tehachapi Valley, these materials having been brought to the seat of deposition by a high grade stream engaged in the rapid dissection of a recently uplifted mountain block. It has been shown further that the later orogenic movement which deformed the Tehachapi Alluvium was characterized by a recurrence of the uplift on the north side of the present Tehachapi Valley. The stream which gave rise to the Tehachapi Alluvium would, by this second uplift, have had the grade, to which it had attained, again accentuated. This accentuation of grade would apply now to the country occupied by the alluvial cone and the latter would consequently be dissected. The dissection of the cone would continue till a grade profile was established, when the stream would begin to meander and evolve an ever-widening flood-plain on a stream-cut terrace. This terrace would be cut out of the alluvium and the rocks adjacent to it or under it indifferently. The history thus sketched appears to be that of the broad stream terrace which has been described as traversing the Tehachapi Alluvium, the Cable lake beds, and the various rocks of the Bed-rock Complex above Cable.

If this interpretation be correct, then it is clear that the drainage, at the time that the terrace was functional as a flood-plain, was *from* the north and not *towards* the north as at present.

Dissection and Reversal of Drainage.—Since its completion the terrace has been deeply dissected and this dissection has been effected by a northerly flowing stream, the present Tehachapi Creek which drains into the Great Valley. In the vicinity of Cable this dissection amounts to 350 feet or more; and in the tributary creek, which comes in from the left from China Hill, and which joins Tehachapi Creek about half a mile above Cable, cutting through granite, schist, limestone, Cable lake beds and Tehachapi Alluvium, the dissection is about 250 feet in depth. The valley of this stream where it cuts through the hard rocks has a width of about 150 feet and in the soft rocks of over 300 feet on its bottom.

Two circumstances seem to have conspired to bring about the reversal of the drainage above indicated. It has been shown that the terrace surface slopes to the south and passes beneath

the modern alluvium of Tehaehapi Valley, or, more particularly, beneath the alluvium of the China Hill eone. What its extent may be beneath this alluvium is unknown but it is clear that the accumulation of this alluvium upon the southern extension of the flood-plain would tend to pound back the waters eoming from the north and eause them to seek another outlet if such were available.

Such an outlet was provided by the headwater erosion of a stream on the Great Valley side of the mountains. The two orogenic movements which have been recorded as affecting the mountains in this direction greatly accentuated the grade of the streams on the north side of the divide, and one of these, the present Tehachapi Creek, caused the divide to migrate southerly till it reached the terrace of the southerly flowing stream, and not only effected its eapture but provided an outlet for its beheaded portion, the waters of which, in greatly diminished volume, were obstructed by the excessive accumulation of alluvium upon its flood-plain. The question now arises as to the cause of this excessive accumulation of alluvium. The answer to this question is very pointedly suggested by a consideration of the geomorphie features of the region which is the source of that alluvium. The alluvium all eomes from a few sharp, torrential cañons which emerge, above grade, upon Tehaehapi Valley, from the straight, bold wall of Tehachapi mountain which forms the western half of the southern boundary of the valley. The geomorphic discordance which these cañons present to the broad, alluviated Tehachapi Valley is in itself ample proof of the fact that the mountain mass whieh they dissect is a fault block. The northern slope of the mountain is steep and on the whole not greatly degraded. This faee has a regular east and west trend, transverse to the strike of the schists and limestones whieh together with granitie rocks make up its mass. The cañons which discharge the alluvium are relatively so insignificant that they do not greatly noteh the longitudinal profile of the mountain and their mouths ean scarcely be perceived at a distance of a few miles. If such evidenee that the face of the mountain is a degraded fault scarp were not sufficient, more direct evidence may be observed at the point where Antelope

Dissected stream-cut terrace at the northwest corner of Tehachapi Valley sloping down *from* the outlet to the valley floor.

Creek emerges upon the valley. Here it is apparent that the apex of the alluvial cone which spreads out from this point across the entire breadth of Tehachapi Valley was established when the rock bottom of the creek within the mountain was much higher than it is at present. The cañon bottom has been corraded down to a depth of 250 feet below the apex of the cone and this deepening of the rocky cañon has necessitated the dissection of the higher part of the alluvial cone. There is thus exposed in the walls of the cañon the contact betwen the buried face of the mountain and the alluvium which reposes against it through a vertical range of 250 feet. This contact, while not absolutely vertical, is so nearly so that the rock surface against which the alluvium rests can be interpreted only as a fault scarp. That is to say, it is the lower portion of the general fault scarp of the mountain front which has been preserved by burial from the greater part of the degradation which has affected the upper portion.

In the recognition of the fault scarp nature of this mountain front we have evidence of a third orogenic movement, and its discreteness in time from the other two movements, which have been recorded as affecting particularly the north side of the present valley, is proved by the fact that the alluvial debris which was produced by the torrential corrasion of the uplifted block, was dejected upon the broad terrace which had been in part cut out of the deformed Tehachapi Alluvium.

Mature Geomorphy.—If now we continue our consideration of the south boundary of Tehachapi Valley into its more eastern part beyond the portion which has just been identified as a fault scarp, we come upon a totally different type of geomorphic expression. Here the valley is bounded on the south by a range of hills of gently flowing profiles and contours. The hill tops are flatly rounded and there are no incisive cañons dissecting them. The slope to Tehachapi Valley is not steep and abrupt but descends as an undulating surface, on the lower parts of which there are remnants of stream terraces strewn with well washed cobbles and pebbles. The height of these hills is probably about 1000 feet above Tehachapi Valley or less than half the height of the fault block mountain immediately to the west

of it. The edge of these mature hills where they meet the floor of Tehachapi Valley is not a straight line, as is the ease with the fault scarp to the west, but is more or less indentate and on the whole sinuous or concave to the north. It is evident from the facts cited that we have here to deal with a quite mature geomorphy which has been entirely unaffected by the disloca-tion upon which the fault bloek to the west was uplifted. When first viewed from a distanee the eontrast between these two por-tions of the south boundary of Tehachapi Valley was so striking that the writer supposed that the underlying roeks must be to-tally different. But an inspection of the ground showed that this was not the case. The rocks which underlie the geomorphically mature hills to the east have the same granitic character as those which form the bulk of the fault block mountain to the west with its bold, youthful features. It seems clear, then, that the fault scarp does not extend eastward beyond the dividing line between these two contrasted types of geomorphy. It follows from this that the dividing line between the fault block mountain and the unfaulted, mature hills immediately to the east of it is a trans-verse or north and south fault, and that the fault block is tilted to the west as well as to the south.

Such a mature geomorphy as has been above indicated is evidently but a remnant of what was once the general eondition of the region, and as this mature surface passes down beneath the floor of Tehachapi Valley, it is probable that we have beneath this part of the valley an earlier mature valley of erosion quite different in its eonfiguration from the modern feature. Towards the eastern outlet of Tehachapi Valley, the north and south sides of the valley converge and here the edge of the mature hills is quite abrupt, but their aeclivity appears to be that of a stream cliff of a stream no longer functional, whose rocky bed is deeply buried in the alluvium from Cache Creek.

Western Boundary of Valley.—There remains to be noted the western boundary of the valley. This is a steep mountain slope of very even and but feebly notehed front, exeept for the gap into Brites Valley. This as will appear later is the revet-ment end of a rather narrow fault bloek and as such has but little water to diseharge to Tehachapi Valley and so has been

A. Degraded fault-scarp forming the western half of the southern boundary of Tehachapi Valley.

B. Mature topography of the mountains forming the eastern half of the southern boundary of Tehachapi Valley.

but slightly affected by stream erosion. It can scarcely be regarded as other than a somewhat degraded fault scarp. The date of its origin is, however, not quite clear. It appears to have antedated the broad terrace which lies at its foot, and may with much probability be referred to the period of orogenic movement which deformed the Cable Lake beds and the Tehachapi Alluvium, since the western edge of the trough in which these formations lie is parallel to its trend and the trough on this side is most acutely deformed so that, as before stated, the Cable Lake beds and the plane of contact between them and the overlying alluvium are in vertical altitude. It is probable, however, as will appear in the sequel, that a second movement of minor extent took place on this same fault at a later date.

GEOLOGICAL HISTORY.

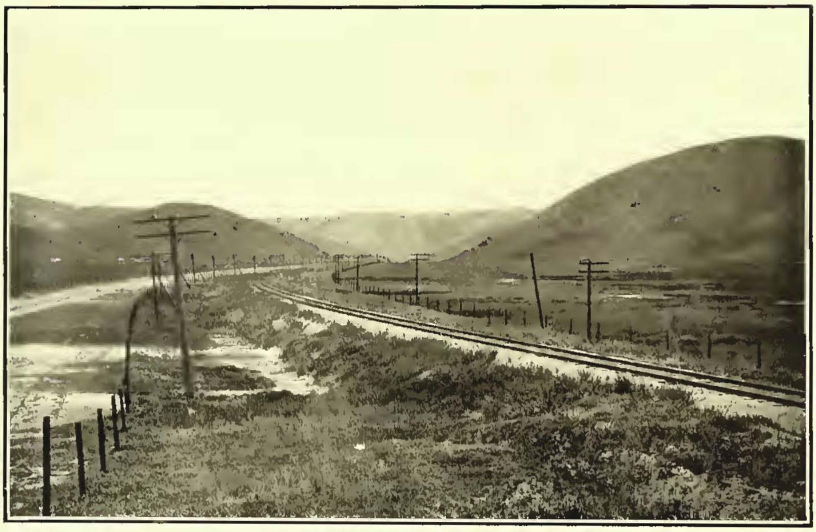
Reviewing now the data that have been presented, the history of the evolution of Tehachapi Valley in so far as the writer has been able to decipher it, in the limited opportunities at his disposal, may be summarily stated. It is not presumed that the statement is complete. When the region is mapped and its features are more closely studied it will doubtless be amplified, and perhaps in some respects modified.

After the profound degradation of the mountain mass which resulted at the time of the mid-Mesozoic revolution in consequence of the invasion of the region by the Sierran batholith, a basin of deposition was developed in which accumulated the sandstones, conglomerates and shales of Cache Valley, and the tuffs and agglomerates of White Rock Valley. The basin was probably lacustrine in character and is probably to be correlated with early Tertiary lake basins of other portions of the Great Basin. These lake beds and tuffs were folded, but not closely appressed, and were then largely removed by erosion, the bed-rock surface upon which they were deposited being in this way in large measure resurrected and subjected to renewed degradation. The next event of which we have note is an orogenic disturbance of the region and the formation of diastrophic valleys bordered by abrupt mountain fronts. This event is an inference based on the occurrence of a coarse alluvium. Alluvium of this character

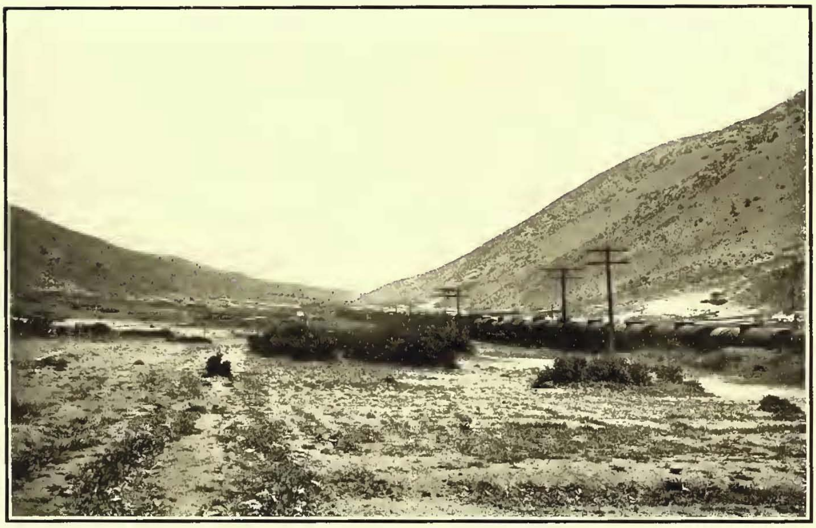
is only known as the product of torrential streams emerging from narrow high grade cañons upon broad open valleys. Such valleys are geomorphically discordant with the erosional features of the mountains whence the streams emerge, and such discordance can usually only be explained as due to diastrophic movements. This accumulation of coarse alluvium was followed by an outburst of volcanic activity, which gave rise to showers of ashes and scoriae and a flow of andesitic lava. Upon the new surface configuration of the region thus established, a lake basin, or possibly several of them, interrupted the normal course of the drainage. In this basin there accumulated the Cable formation consisting of limestones in which fresh water molluscs were entombed, beds of clay, more or less calcareous, and, in the vicinity of incoming streams, beds of gravel and sand. Interstratified with these lacustral beds is an abundance of volcanic tuff also for the most part well stratified. These probably represent the recurrence of volcanic eruptions during the lacustral period, although they may also in large part at least, be explained as the product of the erosion of the surrounding ash mantled country.

This lacustral condition was brought to a close by another orogenic movement which uplifted the mountains to the north of the valley in which the lake lay. The lake was displaced and its deposits were buried under a vast accumulation of coarse alluvium, the Tehachapi Formation, evidently the cone of a torrential stream actively engaged in the dissection of the new mountain mass. The source of the alluvium was from the north.

The next event of which we have record is another orogenic movement ,which deformed the region both by flexure and faulting. At this time the pre-Cable volcanics, the Cable Lake beds, and the Tehachapi alluvium, or at least so much of these formations as are left for our inspection, were together folded in an asymmetric syncline, the most acute deformation occurring on the west side of the trough where the beds are now vertical. At this time the fault scarp which forms the boundary of Tehachapi Valley on the west was also probably formed. This period of acute deformation was succeeded by a period of vertical stream corrasion till the streams attained their base level and then began to evolve a broad flood plain by lateral corrasion. This flood



A. The eastern end of Tehachapi Valley, looking southeast toward the eastern outlet at Cameron.



B. Looking down the eastern outlet of Tehachapi Valley toward Mohave Desert from Cameron.

plain was developed as a very notable feature of the region, being cut across hard and soft rocks alike with great evenness. It is very probable from our general notions of the conditions which attend the evolution of stream-cut plains, that this flood plain stood at a much lower level than its remnants do to-day (4000 feet A. S.). It marks an important datum plane in the evolution of the Sierra Nevada and is the probable correlative of the high valleys of the Upper Kern.*

Up to this time there was probably no such feature as the modern Tehachapi Valley. But now the process of flood plain expansion was abruptly terminated by another orogenic movement, which besides effecting a general elevation of the region far above the base level of the streams, also raised Tehachapi Mountain as a fault block on the south of the present valley and gave the latter its modern configuration as regards its boundaries. The uplift of this block caused the dejection upon the flood plain of the alluvium which forms the greater part of the floor of the valley. Co-eval with this progressive obstruction of the drainage on the flood plain, the head waters of its stream were captured by head water erosion cutting back from the Great Valley into the upraised mountains. The beheaded stream was unable to cope with deluge of torrential debris from the new mountain mass on the south and its course was reversed into the same stream that had captured its head waters. Since this reversal of the drainage the flood plain has been dissected.

The geological history of the eastern outlet of Tehachapi Valley is not so complex. The outlet is a rocky gorge so deeply alluviated as to give a rather broad bottom (200 yards). If we imagine the alluvium removed below the depth of certain wells that have been sunk in it but have not bottomed it, and suppose the rocky slopes projected down we would have a quite narrow and somewhat tortuous mountain gorge. This character establishes the fact that it was not the outlet for the stream that corroded the broad terrace at the western end of the valley. The gorge, *with its present direction of drainage,* could not very well have been evolved *after* the present boundaries of Tehachapi Val-

* Geomorphogeny of the Upper Kern Basin, Bull. Dept. Geol. Univ. Cal., Vol. 3, No. 15.

ley were established. It must, therefore, antedate the modern Tehachapi Valley, *i.e.*, it must antedate the fault block which forms the south boundary of the western half of the valley. This being so the gorge must have been coexistent with the stream which evolved the broad terrace at the west end of the valley, and if this be conceded then the gorge was that of a small eastern affluent of the larger stream. From this line of reasoning we thus reach the conclusion that the drainage of this outlet was also at one time toward the area of the present Tehachapi Valley and that this drainage has been reversed. The causes of the reversal are doubtless two-fold. The uplift which terminated the process of flood plain expansion in this region was without doubt effected by a movement on the great fault which bounds the Sierra Nevada on the east and southeast and which here separates them from the Mohave desert. Such a movement would have beheaded this gorge and have rendered it an easy matter for the rapidly accumulating alluvium in the now mountain-girt Tehachapi Valley to congest the gorge and cause the waters to flow out to Mohave.

It thus appears that both of the outlets of Tehachapi Valley antedate the valley as we know it to-day, and that they are both cases of reversed drainage brought about by orogenic movements, inducing stream capture and the obstruction of the beheaded streams by great alluvial cones.

BRITES VALLEY.

Brites Valley opens into Tehachapi Valley at the southwest corner of the latter through a gap between the fault scarp which bounds both valleys on the south and the northeast corner of Bear Mountain. The trend of the valley is northwest and southeast, in which direction it has an extent of $3\frac{1}{2}$ miles. Its breadth is about $1\frac{1}{4}$ miles. Its southern boundary is the western extension of the same degraded fault scarp as that which bounds Tehachapi on the south. Its northeastern boundary is a mountain wall with a very straight trend and a steep, even, little notched slope, which can only be interpreted as a fault scarp, The bearing of this scarp is northwest and southeast, thus making an angle of about 45° with the strike of the rocks. It may

be referred to as the southwest scarp of Bear Mountain. The western boundary of the valley is a sharp low ridge with north and south trend which spans the space betwen the two converging scarps above noted. This ridge is composed largely of crystalline schists, the strike of which is north and south with the trend of the ridge. The ridge separates Brites Valley from a larger valley on the west known as Cummings Valley, which lies at a much lower level. At the southeast end of the valley a mountain stream comes in from a gorge in the southern scarp. This stream has built up an alluvial fan which is co-extensive with the limits of the valley. The floor of the latter is the surface of this fan and its general slope is down toward the northwest end of the valley, where the outflowing waters have cut a gorge down through the edge of the fan and deep into the underlying bedrock, and so find their way to Cummings Valley. Along the base of the southwest scarp of Bear Mountain, the debris from the degradation of the scarp interdigitates with the edge of the fan and being locally dominant reverses the slope.

The gap through which one enters Brites Valley from Tehachapi is a platform of bedrock or flat-topped ridge between the two valleys. But over this ridge some of the alluvium from the fan which fills Brites Valley has spilled into Tehachapi Valley. A terrace-like shoulder on the south side of this flat-topped rocky barrier, where it is crossed by the wagon road is 544* feet above Tehachapi station. The lowest part of the gap is about 500 feet above Tehachapi station. The floor of Brites Valley at the farm house at its west side, just before entering upon the descent to Cummings Valley, is 446 feet above Tehachapi station. From these figures it will be apparent that Brites Valley is on quite a different level from Tehachapi Valley, a fact, which, considering their immediate juxtaposition and open connection, can only be explained on the hypothesis of their diastrophic origin. The eastern edge of the rocky platform which separates the valleys is in direct line with the western scarp of Bear Mountain and we have in this fact a pointed suggestion that Brites Valley has been dislocated

* This and other altitudes were determined, where not otherwise stated, by means of a mercurial barometer, using Tehachapi station, elevation 3963 feet, as a base.

from Tehachapi Valley by a movement on the fault which established this scarp. The gap which connects the two valleys over the rock platform is about half a mile wide, and the rock platform is with little doubt a surfaee of stream planation. This suggestion is confirmed by the seetion afforded by the gorge at the outlet of Brites Valley. Here the base of the alluvium may be seen reposing upon the bedrock surface, and that surface is again a platform which can only be regarded as a product of stream eorrasion. It would seem, therefore, that, flanking the southwest scarp of Bear Mountain where it bounds Brites Valley, there is a stream terrace in large part buried by alluvium. It seems a fair hypothesis in the absence of any other suggestion to correlate this stream-cut terrace with the broad terraee already described as oecurring in the northwestern portion of Tehachapi Valley; and in this hypothesis we have the farther suggestion that the stream, which evolved the now dislocated and partly buried terrace, flowed out westward through the present site of Brites Valley.

CUMMINGS VALLEY.

Cummings Valley lies immediately to the west of the sharp north-south rocky ridge which forms the western boundary of Brites Valley. It lies at a much lower level than Brites Valley, the drop from the one valley to the other being rather precipitous. In the northeast part of the valley where the wagon road to Bear Valley leaves the main road through Cummings Valley, the altitude is 4056 feet, or 353 feet below the lowest part of Brites Valley, while in the middle of Cummings Valley the altitude is 3924 feet, or 485 feet below Brites Valley. The general contour of the valley is that of a trapezium. Its eastern boundary, as already indicated, trends north and south and has a length of about 4 miles. Its southern boundary is the same east-west, degraded fault scarp which bounds Tehachapi and Brites Valleys on the south. This side is also about 4 miles in length. On the northeast, the southwest scarp of Bear Mountain forms its boundary for about 2 miles. The fourth side of the valley is the more or less serrate edge of a mountainous tract whieh rises to several hundred feet above the level of the valley on the west. The trend of this boundary is north-northeast and its

A. Looking east across Brites Valley. Tehachapi Valley in the distance.

B. Looking southwest across Cummings Valley from near the outlet of Brites Valley.

extent is $5\frac{1}{2}$ miles. The valley thus bounded contains about 13 square miles. There are two principal lines of drainage through the valley. One of these is a stream that comes into the valley at its southeast corner from a high grade cañon in the mountain on the south. This stream has built up an extensive alluvial cone which spreads out over almost the entire valley. The drainage from Brites Valley skirts the northwest edge of this alluvial slope and catches part of the water that flows down the slope of the fan. The entire drainage of the valley converges on its southwest corner and after flowing for a short distance over a bedrock platform enters a narrow gorge and drops rapidly to the Tejon Valley. This gorge descends about 2500 feet in a distance of 4 miles. In the northern part of the valley this alluvial fan meets the waste slope from the southwest scarp of Bear Mountain, and it is the trough between these two opposing slopes which determines the path of the stream from Brites Valley for the first two miles of its course. Beyond this it is crowded over well toward the base of the hills on the northwest side of the valley. The valley thus largely occupied by alluvium is an artesian basin, and in the middle part of the valley a well has recently been sunk to a depth of 125 feet which yields a flow of water at the surface. The mouth of this well is but little above the rock platform over which the drainage flows before escaping from the valley. The well, therefore, proves that the valley, independently of the alluvium which fills it, is a rock rimmed basin. The rocky platform at the southwest corner of the valley is a most interesting feature. It extends out from the base of the hills which bound the valley on its northwest side a distance of half a mile and appears to pass under the feather edge of the alluvial fan with a uniformly flat slope, as is indicated by occasional protuberances of rock for some distance within the area of the alluvium. This platform is interpreted as a surface of stream abrasion and is correlated hypothetically with the similar stream-cut terraces above described, in Tehachapi and Brites Valleys. This platform probably extends as a flanking terrace, but thinly veneered with alluvium, along the greater part of the northwest side of the valley. The hills which rise above the valley on this side harmonize with this

supposition. Although rocky slopes, they have a mature aspect, and the contour of the valley edge is indented with broad, wide-open embayments separated by narrow ridges or points of rock, the crests of which pitch down toward the valley and eventually pass beneath the alluvium. Frequently, off from the base of the hills, there are isolated knobs of rocks and rocky hillocks rising from the alluvium like islands. In general, then, the valley is bounded on this side by geomorphically mature slopes which pass down, a little below the present floor of the valley, into an uneven or lumpy terrace, which, however, is well exposed at the southwestern corner of the valley. There is thus no suggestion of faulting on this side. But such a terrace could not have been evolved with the present drainage scheme or the present configuration of the valley. It clearly antedates the valley. In its southern extension it abuts upon the fault block mountain to the south of the valley and it thus appears to have been cut off in the same way and at the same time as in the case of the stream-cut terrace of Tehachapi Valley, with which it is correlated.

The sudden drop from Brites Valley to Cummings Valley would seem to indicate with little question a fault along the eastern edge of the latter. In general it thus appears that on three sides Cummings is bounded by fault scarps and that as a result of the movements on these a geomorphically mature surface, including a stream-cut terrace, now situated at an altitude of between 4000 and 5000 feet above sea level, and immediately above the edge of the Great Valley, has been tilted down toward the southeast, so as to form a rock-rimmed trough, which has since been filled by alluvium, arising from the degradation of the fault block on the south.

This conception of the character of Cummings Valley involves the recognition of the fact that, before it became filled to its present level by alluvium, it must have been occupied by a lake. Should the central part of the valley, therefore, even be pierced by wells deep enough to reach its rocky floor it may confidently be predicted that such wells will pass through lake sediments. It is questionable whether this lake had an outlet or not. The present catchment area tributary to Cummings Valley is only about 45 square miles, or 3½ times the area of the valley floor.

A. Fault-scarp forming the northeast boundary of Cummings and Brites Valleys. Ridge between the two valleys in the middle ground.

B. Main fault-scarp on the northeast side of Bear Valley, with alluviated fault-terrace in the foreground.

With this limited catchment and an annual rainfall of only $10\frac{1}{2}$ inches it seems quite certain, under present climatic conditions, that the lake could not have attained the expanse necessary for it to reach the level of the lowest part of the rim of the basin. Assuming a run-off to the lake of 50 per cent. of the rainfall for a rocky region such as we have to deal with, and an evaporation of 60 inches per year under a more humid climate than now obtains, it would require a rainfall of at least 35 inches to enable the lake to attain the necessary expanse to escape at the present outlet. Such a rainfall is not an improbability for this end of the Sierra Nevada during glacial times. But it is to be noted that the present drainage outlet of the valley is through a gorge which has been cut down probably 300 feet since the enclosure of the basin by faulting. To attain this increased altitude for the original lowest place in the rim of the basin, the expanse of the lake would be considerably greater than the present area of the valley floor and the rainfall necessary to effect this would be correspondingly greater. A further objection to the lake ever having had an overflow at the original level of the outlet is that we should expect to find strand lines scored on the sides of the valley well above its present floor and no such strand lines have been detected. It seems thus that we are not warranted in assuming that the lake which once occupied Cummings Valley ever had an outlet, and that the drainage outlet which now exists has been evolved without the aid of an overflow. The outlet is a gorge about 300 feet deep at the point where it leaves the valley. Here the geomorphically mature surface to the north of the gorge abuts upon the precipitous mountain scarp which bounds the valley on the south. Where these two surfaces meet there is an asymmetric notch in the mountain profile which constituted, at the formation of the valley, the lowest part of its rim. This notch lay in the line of the fault scarp and could not be missed by a stream cutting back into the very precipitous mountain slope which rises from the Great Valley only a few miles distant. Cummings Valley has been tapped, then, by the headwater erosion of a tributary of Tejon Creek cutting back in a structural trough. A consequence of this conclusion is that the great mountain wall which confines the south end of the Great Valley on

the east, between Caliente and the Tejon Ranch House, is itself a fault scarp, and dates from about the same time as the faulting which gave rise to Tehachapi, Brites and Cummings Valleys.

BEAR VALLEY.

Bear Valley lies to the northwest of Cummings Valley along the base of the southwest scarp of Bear Mountain. Its longer diameter is parallel to the line of the scarp and is about 3 miles in extent. The general width of the valley is about 2 miles. Its area is about 6 square miles. The valley is in two levels. Along the immediate base of the southwest scarp of Bear Mountain is a well defined terrace about 1000 feet wide mantled by the alluvial wash from the scarp which rises steeply at its rear. This terrace is bounded on the southwest by a rather sharp rocky ridge which is in general less than 100 feet above the terrace, and which is notched down to the level of the terrace in a number of places. On the southwest side of this ridge there is an abrupt drop to the level of the main floor of the valley. The latter has an altitude of about 4300 feet at the Fickert ranch house. The terrace is from 300 to 500 feet above this, its highest point being at its southwest end where the wagon road from Bear Valley begins to descend to Cummings Valley. From this culminating point the terrace slopes down to the northwest in the direction of its extension. It is evident that this remarkable feature is a fault terrace. It is a narrow strip of the mountain mass lying between the main fault of the Bear Mountain scarp and a subsidiary parallel fault, the scarp of which forms the descent from the terrace to the main valley. The terraee probably sloped originally down toward the main Bear Mountain scarp and owed that slope to rotation of the fault-bounded bloek. The trough thus formed has since been filled by the debris shed from the scarp above. In its essential features this narrow fault block flanking a major fault scarp is identical with the kernbuts* of the Upper Kern. The main portion of the valley below the fault terrace is constricted near its middle by a narrow sharp ridge of small height which projects as a spur from the moun-

* Geomorphogeny of the Upper Kern Basin. Bull. Dept. Geol. Univ. Cal., Vol. 3, No. 15, p. 331.

Looking down Sycamore Creek from the outlet of Bear Valley to the Tejon Plains.

tain slope on the south, part way across the valley. The geomorphy of this side of the valley is that due to the normal process of erosion and presents no suggestion of faulting. The edge of the valley is indented and the slopes above it are mature.

No stream of importance comes into Bear Valley so that no notable alluvial cone occurs in it as in the other neighboring valleys. But the various streamlets and the general wash from the surrounding mountain slopes have contributed to its infilling and have given it a floor of alluvium except at its west end near its outlet by way of Sycamore Creek to the Great Valley. Here the alluvium which forms the floor of the valley feathers out and there is exposed a rock platform which is the counterpart of that already described near the southwest corner of Cummings Valley. This rock platform passes eastward and southeastward with an almost flat slope beneath the alluvium, and evidently underlies a considerable portion of the valley. It is with little question a remnant of the same system of stream-cut terraces, relics of which have been detected in Tehachapi, Brites, and Cummings Valleys. Its original relation to those relics is not clear, but that is not surprising in a region of such acute diastrophic deformation as that with which we have here to deal. In general, then, Bear Valley may be briefly stated to have originated by the downward tilting of a tract of mature geomorphy on the south, including a stream-cut flood plain, against a dominant fault along the southwest scarp of Bear Mountain; and that against this fault there was left in the down plunge a slab, or kernbut, which failed to drop as far as the rest and the top of which forms the ridge-bordered terrace on this side of the valley. valley.

Beyond this rock platform a narrow gorge opens in the mountain ridge which bounds the valley on the west and through this the waters of the valley find their escape by a very precipitous descent to the Great Valley 3000 feet below and only 4 miles distant. This gorge in its upper part lies on the line of the subsidiary fault scarp and the same suggestion for its development is here made as for the gorge which drains Cummings Valley, *viz.*, that it is due to the headwater erosion of a high grade stream, Sycamore Creek, cutting back in the face of the northwest scarp

of Bear Mountain and finding the notch formed by the subsidiary fault, which notch was originally lower, as it now is, than the analogous notch made by the main southwest fault of Bear Mountain. Prior to the capture of the valley by Sycamore Creek it must have been occupied by a lake, since it is entirely rock rimmed, but the hydrographic basin which includes the valley is so small relatively to the area of the valley, that it is quite improbable that the lake had an outlet by rising to the level of the notch which was afterward deepened by the headwater erosion of Sycamore Creek.

University of California,
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